PRELIMINARY STUDIES ON BIOLOGICAL CONTROL OF THE MULBERRY PSYLLID

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This is a brief summary of the studies on biological control of the mulberry psyllid.

Twelve species (*Menochilus sexmaculatus, Coelophora chinensis, Coccinella octomaculata, Coelophora circumusta, Lemnia swinhoei, Lemnia biplagiata, Leis dimidiata, Propylaea japonica, Coccinella septempunctata, Synonycha grandis, Cryptogonus horishanus, Stethorusloi saeji*) of the predacious ladybug, which fed on the mulberry psyllid, *Paurocephala psylloptera* Crawford were found in the mulberry grove at specialized sericultural areas in Taiwan. Studies were initiated to (1) determine the distribution and population density of nine more abundant species, and (2) compare the seasonal population fluctuations of four major ladybugs with those of the psyllid. The population densities of the 9 ladybug species in 4 areas are summarized in Fig. 1. All ladybug species were found to overwinter in the adult stage. *Menochilus sexmaculatus* (Fabricius) had the highest density and was present in all of the 4 areas studied. The seasonal population fluctuations are given in Fig. 2. Results showed that the population flucturations of *M. sexmaculatus* were significantly correlated to those of the mulberry psyllid.

The above results showed that *M. sexmaculatus* is definitely the key species with promise for biological control of the mulberry psyllid. Thus detail studies on its development, survival and prey consumption were conducted. The results are summarized as follows. The developmental durations of *M. sexmaculatus*, fed with green peach aphids, *Myzus persicae* (Sulzer) and mulberry psyllids, were similar, but the survival rates were higher when the ladybug was fed with the aphids (Table 1). The total amount of aphids consumed by the larval stage of *M. sexmaculatus* at 25°C was 74.7, and that of psyllid 304.2. (Table 1, 2)

In order to utilize *M. sexmaculatus* in the biological control program, further studies included (1) the development and reproduction of *M. sexmaculatus* at various temperatures, (2) the effect of *M. sexmaculatus* on the psyllid population density, (3) the population fluctuations of both the ladybug and the psyllid in insecticide treated and untreated groves, and (4) the proper timing for the chemical control of the psyllid and protection of the ladybug and the silkworm.

The results are summarized as follows. The duration of each stage and fecundity of *M. sexmaculatus* at 3 temperatures were listed in Table 3. The intrinsic rate of increase (r being 0.105, 0.165, 0.248, respectively), mean generation time (T being 51.97, 30.07, 19.52 days, respectively) and net reproductive rate (R_o being 230.89, 143.92, 126.55, respectively) at 3 temperatures were computed from the life table data (Table 4).

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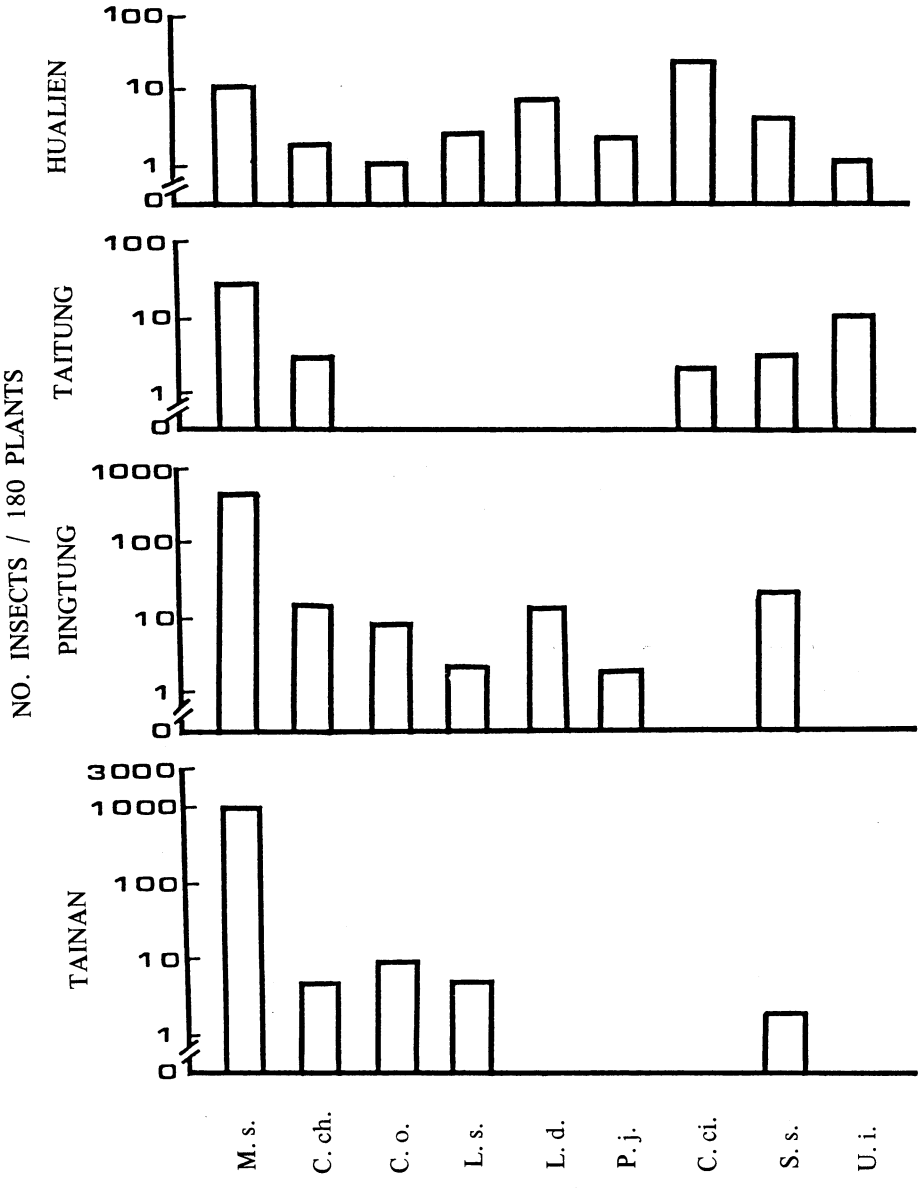

Fig. 1. Population densities of nine species of ladybugs found in the mulberry groves at Tainan, Pingtung, Taitung and Hualien, June, 1982.

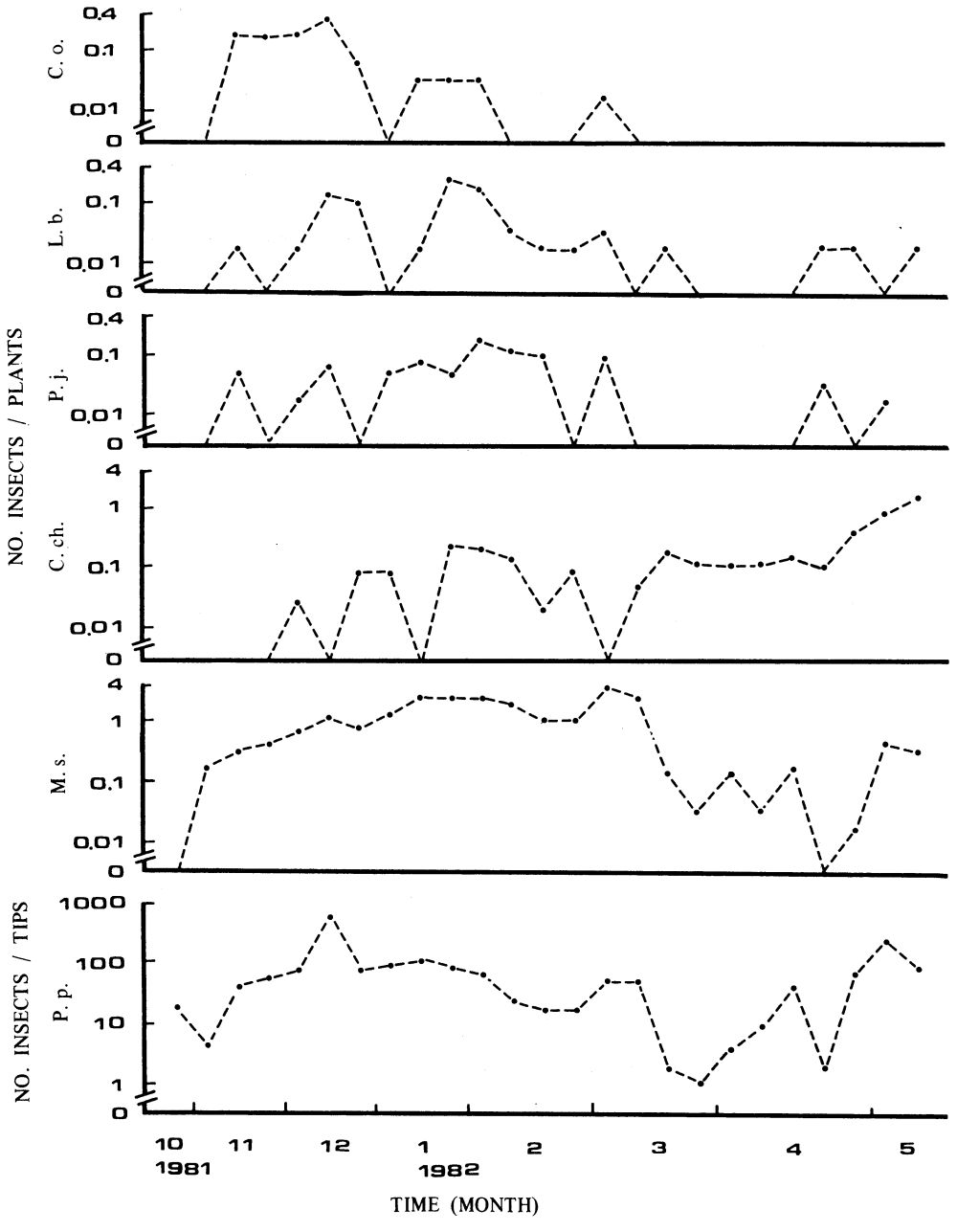

Fig. 2. Population densities of the mulberry psyllids and five species of ladybugs found in the experimental mulberry grove at Wufeng, Oct., 1981 – May, 1982.

Table 1. Developmental duration and survival rate of each stage of *Menochilus sexmaculatus* fed with mulberry psyllids or aphids in the laboratory at 18°C and 25°C, 70% r.h.

Stage	Food	°C	Duration (days) mean ± s.d.	Survival rate (%)
Egg	Psyllids	18	4	85.50
		25	2	100.00
	Aphids	18	3.76±0.44	88.10
		25	2.40±0.50	100.00
Larva 1st	Psyllids	18	2.80±0.81	94.07
		25	1.45±0.50	97.30
	Aphids	18	4.16±0.85	80.95
		25	1.80±0.62	78.57
2nd	Psyllids	18	1.70±0.65	95.93
		25	1.16±0.37	98.55
	Aphids	18	2.48±0.51	100.00
		25	1.10±0.30	93.55
3rd	Psyllids	18	2.83±1.15	90.29
		25	1.47±0.50	94.21
	Aphids	18	2.08±0.64	100.00
		25	1.25±0.44	96.15
4th	Psyllids	18	5.57±1.14	73.56
		25	2.43±0.54	77.89
	Aphids	18	4.24±0.93	96.67
		25	2.15±0.49	90.91
Pupa	Psyllids	18	6.73±1.14	46.88
		25	3.25±0.52	66.22
	Aphids	18	6.96±0.20	86.21
		25	2.65±0.49	100.00
Total	Psyllids	18	23.63±1.92	24.02
		25	11.76±0.44	46.59
	Aphids	18	23.64±1.55	59.43
		25	11.35±1.23	64.25

Table 2. Consumption of the aphids or psyllids by *Menochilus sexmaculatus* in the laboratory at 18°C and 25°C, 70% r.h.

Stage		°C	No. insects consumed/day (mean ± s.d.)	
			Aphids	Psyllids
Larva	1st	18	2.4 ± 1.7	–
		25	3.6 ± 1.5	12.4 ± 9.50
	2nd	18	3.7 ± 3.3	–
		25	7.2 ± 2.0	29.0 ±13.90
	3rd	18	8.0 ± 3.9	–
		25	12.1 ± 4.7	48.2 ±20.10
	4th	18	14.6 ± 9.1	–
		25	21.0 ± 4.0	74.8 ±26.10
Adult		18	17.4 ±10.3	–
		25	–	82.5 ±14.30

Table 3. Duration of each developmental stage and fecundity of *Menochilus sexmaculatus* at three temperatures

Stage		20°C[1]	26°C[2]	30°C[1]
Egg		3.9± 0.45	2.5 ± 0.6	1.3 ± 0.50
Larva	1st	1.7± 0.59	0.9 ± 0.2	0.8 ± 0.25
	2nd	2.4± 0.58	1.2 ± 0.48	0.9 ± 0.22
	3rd	2.8± 0.84	1.5 ± 0.61	1.1 ± 0.41
	4th	5.3± 0.97	3.2 ± 0.73	2.0 ± 0.49
Pupa		6.8± 0.39	5.1 ± 0.49	3.0 ± 0.36
Adult	Preovipositing	2.6± 0.87	1.3 ± 0.75	1.2 ± 0.56
	Ovipositing	52.8± 13.02	50.6 ± 21.57	33.6 ± 9.58
	Male longevity	80.3± 14.58	46.6 ± 20.89	39.6 ± 13.06
	Female longevity	83.1± 14.67	64.8 ± 26.38	40.5 ± 14.79
	Fecundity (No. egg/female)	540.2±225.26	549.3 ±248.01	643.0 ±329.88

[1] mean ± s.d. of 150 replicates; ladybugs fed with aphids.
[2] mean ± s.d. of 150 replicates; ladybugs fed with psyllids.

Table 4. The intrinsic rate of increase (r), net reproductive rate (R_o), and mean generation time (T) of *Menochilus sexmaculatus* at three temperatures

°C	R_o	T	r
20	230.89	51.97	0.105
26	143.92	30.07	0.165
30	126.55	19.52	0.248

In tests under greenhouse conditions, the control of the mulberry psyllid by *M. sexmaculatus* was found to be most efficient when a ratio of 1 ladybug to 200 psyllids was set up (Table 5). Field tests showed that populations of both the ladybug and the psyllid declined soon after the spray of insecticide (Fig. 3). Recovery of the population was found to be faster in the ladybug than in the psyllid. Bioassay data indicated that the residual effects of Fenthion, Heptenophos, Metasystox, and DDVP were shorter whereas Monocrotophos, Dicrotophos, and Carbofuran were longer, thus the latter should not be applied in the mulberry grove during the silkworm rearing period (Table 6).

Table 5. Efficacy of biological control of the mulberry psyllid by the ladybug in the green-house

No. of ladybug	No. of mulberry psyllid and % of control								
	before tr.	1 wk. tr.		2 wk. tr.		3 wk. tr.		4 wk. tr.	
	No.	No.	% control	No.	% control	No.	% control	No.	% control
1	135.8	46.3	62.98	30.9	74.94	8.6	92.32	1.4	98.40
	222.8	66.8	67.45	56.4	72.12	25.6	86.07	8.2	94.30
	430.2	343.9	13.20	279.2	28.52	212.0	40.27	181.0	34.36
2	125.3	10.8	90.64	3.9	96.57	0.1	99.99	0.0	100.00
	230.6	72.2	66.00	31.8	84.81	32.4	82.97	11.9	91.95
	426.1	147.7	62.36	82.5	78.68	29.1	91.72	7.1	97.40
	838.2	708.6	8.21	596.7	21.60	607.8	12.11	537.2	1.60
4	147.3	2.3	98.30	0.0	100.00	0.0	100.00	0.0	100.00
	419.3	95.4	75.31	36.0	90.55	21.0	93.93	0.0	100.00
	842.7	357.2	53.98	302.8	60.43	167.4	75.92	89.1	83.51
	1273.5	897.4	23.49	756.1	34.61	776.4	26.10	509.3	37.61
6	127.9	0.8	99.32	0.0	100.00	0.0	100.00	0.0	100.00
	641.3	250.8	57.54	23.4	95.98	0.0	100.00	0.0	100.00
	1263.8	889.6	23.57	357.3	68.66	203.4	80.49	164.7	79.67
	1882.8	1078.3	37.82	834.2	51.20	609.3	60.77	537.4	55.47
CK	223.9	206.2	0.00	203.4	0.00	184.8	0.00	143.6	0.00

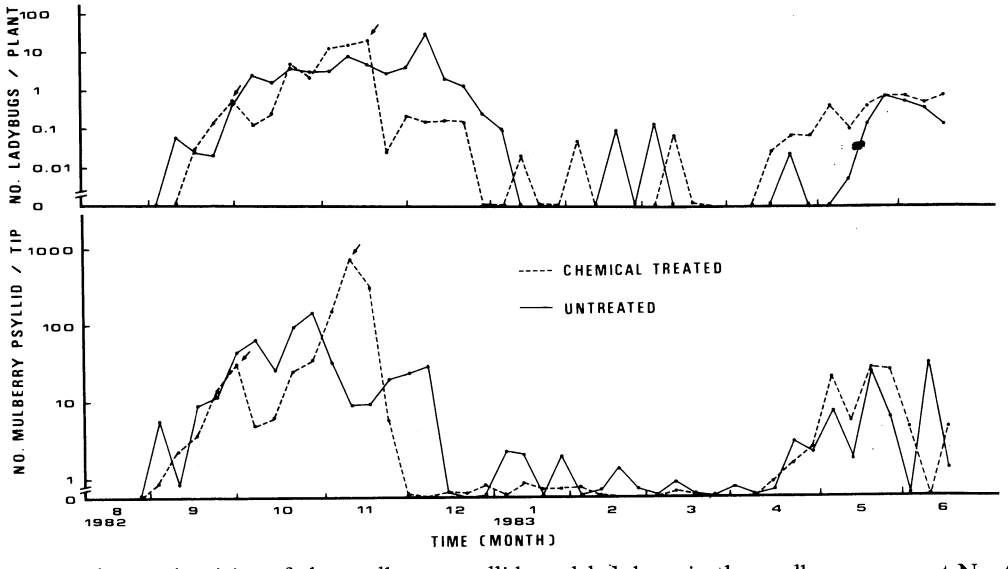

Fig. 3. Population densities of the mulberry psyllids and ladybugs in the mulberry grove at Nantou.

Table 6. Bioassay of the chemical residual effects on the silkworm larvae fed with treated mulberry leaves

Insecticide	ppm	Mortality (%) after treatment			
		10 days	15 days	20 days	25 days
		3rd Instar			
Monocrotophos	500	55	83.3	0	0
	375	53.3	85	0	0
	250	41.7	0	0	0
Dicrotophos	500	6.9	0	0	0
	375	3.3	0	0	0
	250	1.7	0	0	0
Carbofuran	500	45	36.7	5	3.3
	375	10	3.3	5	0
	250	15	3.3	1.7	0
CK		0	0	0	0
		4th Instar			
Monocrotophos	500	96.33	90.0	51	0
	375	92.7	81.7	50	0
	250	48.3	8.0	0	0
Dicrotophos	500	6.7	1.7	0	0
	375	1.7	0	0	0
	250	1.7	0	0	0
Carbofuran	500	68.3	33.3	20	3.3
	375	36.7	6.7	3.3	1.7
	250	28.3	0	1.7	0
CK		0	0	0	0
		5th Instar			
Monocrotophos	500	100	86.7	48.3	66.7
	375	100	78.3	35	36.7
	250	100	23.3	8.3	1.7
Dicrotophos	500	100	0	0	0
	375	96.7	0	0	0
	250	56.7	0	0	0
Carbofuran	500	100	41.7	21.7	1.7
	375	100	35	5	1.7
	250	98.3	11.7	3.3	0
CK		0	0	0	0